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purifn. by blowing an inert gas. Preferably, the specifications of the ceramic plates for filtration are 10−30 ppi for the 1st stage, 40−50 ppi for the 2nd stage, and 30−40 ppi for the 3rd stage; the thickness of the fluxes in both stages is 5−8 mm; the pulse frequency in the gas purifn. process is 20−50 Hz; and the pore size of the blowing plug for gas purifn. is 10−100 μm. The title process can effectively reduce the contents of H and oxide inoculations.

135: 333991p **Manufacture of bulk zirconium and neodymium based amorphous alloys by spray casting.** Xu, Min; Sun, Wensheng; Zhang, Fengjun; Quan, Mingxiu (Metal Institute, Chinese Academy of Sciences, Peop. Rep. China) **Faming Zhuanli Shenqing Gongkai Shuomingshu CN** 1,300,863 (Cl. C22C1/00), 27 Jun 2001, Appl. 99,122,647, 17 Dec 1999; 8 pp. (Ch). The Zr or Nd alloy is manufd. by melting the component metals in an elec. arc furnace in Ar under electromagnetic stirring for 2−3 times to obtain a master alloy, placing the master alloy in a quartz cylinder with a nozzle, melting the master alloy in the quartz cylinder in vacuum (10^{-2}−10^{-3} torr) by induction heating, and spraying the obtained melt through the quartz nozzle with Ar at 0.2−1.5 kg/cm² into a Cu mold.

135: 333992q **Apparatus for heat treatment of aluminum melt in vacuum or inert gas.** Nakamura, Masatomo; Sato, Kenjiro; Matsubara, Hirokazu (Daido Special Steel Co., Ltd., Japan) **Jpn. Kokai Tokkyo Koho JP** 2001 300,698 (Cl. B22D1/00), 30 Oct 2001, Appl. 2000/122,172, 24 Apr 2000; 4 pp. (Japan). A molt treatment app. has a tank for storing a molt under an atm. pressure and a treatment tank in which the molt supplied through a channel provided in the bottom of the storing tank is heated in vacuum or inert gas. The app. comprises a check valve that can close and open the melt supply channel, a gas supply pipe for blowing gas into the melt, a detector for detecting the gas pressure inside the gas supply pipe, and a valve control circuit which outputs a valve closure command to the drive mechanism operating the valve when the pressure detected by the gas detector exceeds the preset pressure. A drop in the melt depth in the storing container to below the prescribed level is prevented, and the treatment container is reliably isolated from the atm.

135: 333993r **Refining of high purity Fe−Ni alloy suitable for etching in manufacture of shadow mask.** Fujimoto, Kaoru (Hitachi Metals, Ltd., Japan) **Jpn. Kokai Tokkyo Koho JP** 2001 303,123 (Cl. C21C7/00), 31 Oct 2001, Appl. 2000/125,878, 26 Apr 2000; 4 pp. (Japan). The alloy (contg. Ni 20−80%, Fe bal.) is refined and de-oxidized by vacuum induction melting with Ar gas blown into the molten metal. Preferably, Al deoxidizer (<0.1 kg/t) and other deoxidizers (<0.1 kg/t × equiv. ratio to Al) are added before the termination of Ar gas blowing.

135: 333994s **Separation of iron and copper from iron−copper alloy by applying magnetic field.** Asai, Shigeo; Sung, Mun Gyu; Chino, Yasumasa (Nagoya University, Japan) **Jpn. Kokai Tokkyo Koho JP** 2001 303,146 (Cl. C22B9/02), 31 Oct 2001, Appl. 2000/127,135, 27 Apr 2000; 6 pp. (Japan). The process comprises stirring and applying strong magnetic field to the Fe−Cu melt during its solidification process (melt, solid and liq. coexisting state, solidified state). Preferably, the stirring force is ≥100 W/ton; and the magnetic field is ≥5 T. The title process can be used for removal of impurities.

135: 333995t **Die with ceramic coating modified by ion implantation for die casting and manufacture of die-cast products.** Yamazaki, Hiroshi; Negishi, Hiroaki (Olympus Optical Co., Ltd., Japan) **Jpn. Kokai Tokkyo Koho JP** 2001 300,710 (Cl. B22D17/22), 30 Oct 2001, Appl. 2000/125,825, 26 Apr 2000; 6 pp. (Japan). A die for die casting comprises ≥1 movable core linked to the movement of the die. The core has a protrusion for forming a recess in a die-cast product obtained by pouring a molten metal into a cavity into which the core is inserted. At least the protruding portion of the die is coated with a ceramic layer modified by ion implantation. The die is used for casting Al alloys, Mg alloys, or Zn alloys.

135: 333996u **Casting of Fe−Ni alloy ingot for shadow mask application.** Fujimoto, Kaoru; Hara, Kenichiro (Hitachi Metals, Ltd., Japan) **Jpn. Kokai Tokkyo Koho JP** 2001 300,694 (Cl. B22D7/00), 30 Oct 2001, Appl. 2000/122,790, 24 Apr 2000; 4 pp. (Japan). The ingot that is to be rolled into thin sheet for etching is obtained by casting the molten alloy (Ni 20−80%, Fe bal.) of >1500° into a ingot mold. Preferably, a shalow ingot mold that weighs ≥1.1 of the wt. of the molten alloy is used. The process improves the etching eveness of the thin sheet due to existence of columnar crystals.

135: 333997v **Furan no-bake foundry binders for sand molds and cores.** Chang, Ken K.; Hutchings, David A. (Ashland Inc., USA) **PCT Int. Appl. WO** 01 81,024 (Cl. B22C1/22), 1 Nov 2001, US Appl. 559,766, 27 Apr 2000; 22 pp. (Eng). The furan cold-hardening (no-bake) binders for sand molds and cores contain: (a) reactive furan resin at nominally 1−50 parts by wt.; (b) furfuryl alc. at 10−80 parts; (c) hardener based on Lewis acid catalyst, and optionally conventional furan-resin catalyst; and (d) optional polyol at 0.1−30 parts (esp. resorcinol at 0.1−20 parts), bisphenol at 1−30 parts, and/or organosilane (as coupling agent at 0.01−1.0 parts). The Lewis acid catalyst is preferably Zn chloride, and the conventional furan catalyst is a sulfonic acid at the wt. ratio of 1:8 to 8:1. The fresh resin−bonded sand mix is hardened in a pattern box for mold manuf., removed, and used as foundry mold for casting of molten metal. The cold−hardening binder shows decreased emission of vapor products from the molds and cores in casting of gray iron and steel.

135: 333998w **Single crystal nickel−based heat−resistant alloys, and gas turbine blades made of same alloys.** Okada, Ikuo; Takahashi, Koji; Izutsu, Daisuke; Kawai, Hisataka (Mitsubishi Heavy Industries, Ltd., Japan) **Jpn. Kokai Tokkyo Koho JP** 2001 294,959 (Cl. C22C19/05), 26 Oct 2001, Appl. 2000/115,164, 17 Apr 2000; 8 pp. (Japan). The single crystal is Ni alloys contg. Cr 7.5−10, Co 4.5−6, Mo 0.5−3, W 7−9, Al 4.5−6.5, Ta 5.5−7.0, and C 0.005−0.07 and/or B 0.001−0.006 wt.%. The alloys may further contain ≥1 selected from 0.01−0.2 wt.% Hf, 0.01−2 wt.% Re, 0.01−0.03 wt.% Pt, 1−100 ppm Ca, 1−100 ppm Mg, and 0.5−2 wt.% of Ti. Gas turbine blades made of the Ni alloys are also claimed. The alloys show high strength at high temp. and can be prepd. by monodirectional casting.

135: 333999x **Aluminum alloy ingots showing excellent thermal conductivity.** Kitaoka, Sanji (Nippon Light Metal Co., Ltd., Japan) **Jpn. Kokai Tokkyo Koho JP** 2001 294,962 (Cl. C22C21/00), 26 Oct 2001, Appl. 2000/110,228, 12 Apr 2000; 4 pp. (Japan). The Al alloy ingots contain 1.0−6.0 wt.% of Ni and <1.0 wt.% (for each) of other elements, wherein ≥20 area% of the alloys is occupied by Al−Ni eutectic ppts. The Al alloy ingots may contain Ni 1.0−6.0, Si 0.1−0.6, Mg 0.2−0.9, Fe 0.1−0.8, and optionally Ti 0.005−0.15 and/or B 0.0001−0.05 wt.%. The ingots are suitable for heat sinks for elec. devices.

135: 334000b **Aluminum alloy plates showing high crush resistance, and their preparation.** Anno, Masamichi; Takagi, Yasuo; Takeshe, Osamu (Toyota Motor Corp.; Kobe Steel, Ltd., Japan) **Jpn. Kokai Tokkyo Koho JP** 2001 294,965 (Cl. C22C21/06), 26 Oct 2001, Appl. 2000/110,884, 12 Apr 2000; 7 pp. (Japan). The Al alloy plates contain Si 0.4−0.8, Mg 0.4−0.8, Fe ≤0.3, and Mn ≤0.3 wt.%, and satisfy [r_t = grain size in the plate thickness direction of a cross section along with the rolling direction; r_l = grain size in the rolling direction; av. r_t ≤100 μm; r_l/r_t ≥2 (as av.)]. The Al alloy plates satisfying the grain size are press formed and aging treated to give members having ≥230 MPa yield strength. Alternatively, Al alloy plates of the compns. are press formed and aging treated to give members satisfying the grain size and having ≥230 MPa yield strength. The plates are suitable for automobile parts.

135: 334001c **Chromium−nickel−iron alloys with high corrosion resistance at high temperature, and parts made of same alloys.** Totsui, Toshimitsu (Mitsubishi Heavy Industries, Ltd., Japan) **Jpn. Kokai Tokkyo Koho JP** 2001 294,987 (Cl. C22C27/06), 26 Oct 2001, Appl. 2000/109,729, 11 Apr 2000; 6 pp. (Japan). The alloys contain Ni 17−23, Cr 45−55, impurities of Si and Mn ≤0.4 wt.% (as total), and balance Fe. The alloys may further contain 0.5−2 wt.% of W or 1.0−3 wt.% of Co. Corrosion resistant parts made of the alloys used in high−temp. corrosive environment are also claimed. The parts are suitable for boilers in power generation plant.

135: 334002d **Precipitation−hardened aluminum−based alloy with excellent fatigue strength under average tensile stress.** Dono, Hajime; Sugimoto, Yoshihiko; Iwanaga, Shogo; Seguchi, Takeshi; Suzuki, Takamasa; Suzuki, Yoshinao (Toyota Central Research and Development Laboratories, Inc.; Toyota Motor Corp., Japan) **Jpn. Kokai Tokkyo Koho JP** 2001 303,163 (Cl. C22C21/02), 31 Oct 2001, Appl. 2000/127,861, 27 Apr 2000; 5 pp. (Japan). The Al alloy having pptn. hardening Al phase contains Ti 0.1−0.3, Si 4−12, Cu 0−1, Mg 0−0.5 (≠0), Fe 0−0.7, and Mn 0−0.7%. The alloy may be a cast alloy for cylinder heads of automotive engines.

135: 334003e **Ti−Ni alloy with shape memory and formability suitable for microactuators.** Ishida, Akira; Miyazaki, Shuichi (Japan) **U.S. Pat. Appl. Publ. US** 2001 35,236 (Cl. 148−402; C22C14/00), 1 Nov 2001, JP Appl. 1998/65,936, 16 Mar 1998; 11 pp. (Eng). The shape−memory alloy contains 50−66 at.% of Ti with Ni as the balance, shows ductility ≥15% at room temp., and can be prepd. as an amorphous brittle film by conventional vapor deposition. The ductile shape−memory alloy is obtained by: (a) crystn. of amorphous Ti−Ni alloy deposit for <1 h at 600−900 K; and (b) slow cooling to room temp. to prevent the pptn. of Ti_2Ni phase on grain boundaries.

135: 334004f **Nickel microalloyed with Mg and Al for thermionic cathodes of cathode−ray tubes.** Roquais, Jean−Michel; Poret, Fabian; Le, Doze Regine (Thomson Licensing S.A., Fr.) **Eur. Pat. Appl. EP** 1,152,447 (Cl. H01J1/142), 7 Nov 2001, FR Appl. 2000/5,306, 26 Apr 2000; 9 pp. (Eng). The Ni alloy for manuf. of cathodes in cathode−ray tubes is microalloyed with 0.01−0.1% Mg, and a controlled amt. of Al (esp. 0.01−0.02%) selected for good adhesion of emissive oxide layer to the alloy base. The typical microalloyed Ni with good adhesion of oxide layer contains 0.02% Mg and 0.006% Al, vs. occasional adhesion problems at 0.04% Mg and 0.02% Al.

135: 334005g **Solid free−form fabrication of articles by upward spraying of molten metal droplets on a substrate.** White, Dawn Roberta; Wilkosz, Daniel Edward; Subramaniam, Sankaran (Ford Global Technologies, Inc., USA) **U.S. US** 6,306,467 (Cl. 427−470; B05D1/36), 23 Oct 2001, Appl. 332,437, 14 Jun 1999; 5 pp. (Eng). The free−form article is fabricated by: (a) providing a suitable stable substrate; (b) forming molten metal or alloy droplets, esp. by melting of wire feed; and (c) precision spraying the molten droplets upward against the substrate, for deposition and solidification to form a net−shape article. The molten droplets are typically flattened upon impact with the substrate, and are solidified with a smooth surface finish. The upward stream of molten droplets is typically generated by elec.−arc welding torch fed with ≥1 wires for melting. The process is suitable for fabrication of articles without conventional melt casting in molds.

135: 334006h **Composites with Mo silicides and Si carbide for heat−resistant refractory material.** Gnesin, B. A.; Epel'baum, Boris Markovich; Gurzhiyants, P. A. (Institut Fiziki Tverdogo Tela RAN, Russia) **Russ. RU** 2,154,122 (Cl. C22C29/02), 10 Aug 2000, Appl. 98,113,544, 7 Jul 1998; No pp. given (Russ). The heat−resistant composite material contains Mo_5Si_3 and Mo_5Si_3C at 7.5−67 total, SiC 20−75, and $MoSi_2$

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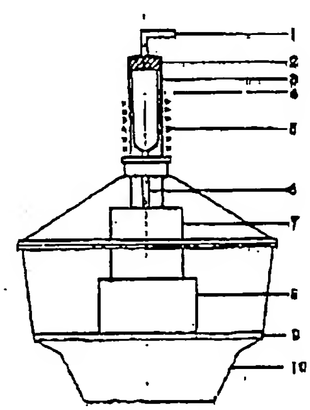
[54]发明名称 一种块体非晶态合金的制备方法

[57]摘要

一种块体非晶态合金的制备方法，其特征在于：将母合金置于石英套筒内的石英喷嘴中；抽石英喷嘴和玻璃真空体内的真空，充入高纯氩气，反复抽真空，充氩气2-3遍后，保持真空体内的负压为$10^{-2}-10^{-3}$Torr；通过高频感应线圈将母合金加热熔化；给石英喷嘴瞬时通入0.2~1.4kgf/cm²压力的高纯氩气，将母合金熔体高速瞬时铸入铜模中。本发明可以有效地提高非晶形成能力。



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权 利 要 求 书

1. 一种块体非晶态合金的制备方法，适用于块体非晶态合金的制备，包括Zr系、Nd系等，其特征在于：首先将纯金属组元在高纯氩气保护下置于电弧炉中，采用电磁搅拌进行熔化，反复熔化2~3遍，制成母合金；将母合金置于石英套筒内的石英喷嘴中，用夹具将其固定，并密封夹具；通过真空抽气系统，抽石英喷嘴和玻璃真空体内的真空，当真空度达到要求时，关闭真空抽气系统，充入高纯氩气。反复抽真空、充氩气2~3遍后，保持真空体内的负压为10^{-2}~10^{-3}Torr；起动高频感应加热装置，通过高频感应线圈将母合金加热熔化；熔化后，通过电磁阀控制浇铸时间和气体压，给石英喷嘴瞬时通入0.2~1.4kgf/cm^{2}压力的高纯氩气；由于石英喷嘴和真空体内产生很大的瞬时气压差，将母合金熔体高速瞬时铸入铜模中.

2. 按权利要求1所述块体非晶态合金的制备方法，其特征在于采用玻璃真空体。

3. 按权利要求1所述块体非晶态合金的制备方法，其特征在于：浇铸时间和气体压力采用电磁阀控制。

4. 按权利要求1、2所述块体非晶态合金的制备方法，其特征在于气体压力为1.2~1.4kgf/cm^2。

说　明　书

一种块体非晶态合金的制备方法

本发明涉及块体非晶态合金的一种制备方法，具体地讲，本发明涉及采用气压差铸入法制备块体非晶态合金。

非晶态合金具有许多优异的物理、化学和机械性能，具有晶态金属难以达到的高强度、高硬度、高延展性、高磁导率、高耐蚀性以及优异的电性能、抗辐照能力和较好的催化及贮氢能力，因而在现代工业、国防、通讯等领域都具有重要的应用价值。但是，非晶态合金的研究和应用受到其样品尺寸的限制，这是由于采用熔体急冷等制备方法制备非晶态合金时通常需要极大的冷却速度(每秒十万度以上)，这样样品在某一个方向上的尺寸必然很小，一般小于 100μm。为此，有重要实际应用的非晶态合金只能以薄带、薄片、细丝或粉末的形式制备出来，使这种材料在实际应用中受到很大限制。制备出三维块体非晶态合金已成为一项共同关注的世界难题。

近年来，在块体非晶态合金的制备方面取得了突破性进展。日本东北大学的 A. Inoue 首先在 La 基合金中制备出 3mm 厚的块体非晶。随后，美国加州理工学院的 W. L. Johnson 在 Zr 基合金中制备出 14mm 厚的块体非晶。在近几年中，以美、日、德为主的研究单位展开了大量深入的研究工作，因此近期在国际范围掀起了一个块体非晶态合金的研究热潮。最近的性能测试结果表明，Zr 基块体非晶态合金不仅具有极高的抗拉强度，而且具有与常规高合金钢相近的断裂韧性。这是十分罕见的优异性能，具有很大的应用前景。非晶态合金一般具有很低的弹性模量，因此可用作高弹性材料。用块体非晶态合金制造的高尔夫球杆端头比目前采用的 Ti 合金性能优越。块体非晶态合金的另一优点是易于加工。由于非晶态合金实际上是过冷液态，因此可采用一次近成型压力加工工艺制造出形状复杂的工件，工艺简便，成本低。另外，一些块体非晶态合金具有优异的软磁或硬磁性能，可用作磁记录和磁头材料，在通讯等方面有着很大的应用前景。

目前，块体非晶态合金的制备方法主要有：水淬、模铸、压铸、吸铸等方法。水淬法是将熔化的母合金直接淬入冷却介质中，方法简单。但由于冷却介质的阻力作用，其冷却速度较低，在很多合金系中都不易形成块体非晶态合金。水淬法制备出的合金还有两种严重的缺陷，一是形状很难控制，二是表面有氧化现象。模铸法是将熔化的母合金直接铸入金属模具中，可以显著提高母合金的冷却速度。但是由于

母合金熔体与金属模具内的压差接近，造成铸入时流速慢，导致冷却速度降低。另外，喷嘴内的合金熔体氧化现象严重。由于不同合金熔体氧化程度不同，使喷嘴底部开口直径大小很难控制，而且制备出的块体非晶也存在着表面氧化现象。压铸法和吸铸法可以避免水淬法和模铸法的缺点，但其制备装置复杂，操作复杂，成本高。

本发明的目的在于提供一种块体非晶态合金的制备方法，该方法可以有效地提高非晶形成能力。

本发明提供的制备方法，适用于块体非晶态合金的制备，包括 Zr 系、Nd 系等，其特征在于：首先将纯金属组元在高纯氩气保护下置于电弧炉中，采用电磁搅拌进行熔化，反复熔化 2~3 遍，制成母合金；将母合金置于石英套筒内的石英喷嘴中，用夹具将其固定，并密封夹具；起动真空抽气系统，抽石英喷嘴和玻璃真空体内的真空，当真空度达到要求时，关闭真空抽气系统，充入高纯氩气。反复抽真空、充氩气 2~3 遍后，保持真空体内的负压为 10^{-2}~10^{-3}Torr；起动高频感应加热装置，通过高频感应线圈将母合金加热熔化；熔化后，通过氩气瓶上连接的电磁阀，控制浇铸时间和气体压力，给石英喷嘴瞬时通入一定压力（1.2~1.4kgf/cm^2）的高纯氩气，由于石英喷嘴和真空体内产生很大的瞬时气压差，将母合金熔体高速瞬时铸入铜模中，形成块体非晶态合金。

本发明的关键在于浇铸温度、浇铸时间和气体压力。本发明具有下述优点：

1. 解决了水淬法和模铸法制备块体非晶态合金时的氧化问题和石英喷嘴底部开口直径大小不易控制的问题。通过反复进行的抽真空和充高纯氩气，不但避免了母合金熔体的氧化，也解决了喷嘴开口大小难以控制的问题。

2. 由于采用电磁阀控制氩气压力和氩气充入时间，可以人为调节和控制气体压力和浇铸时间。

3. 由于石英喷嘴内的母合金熔体采用石英导流管铸入铜模中，不但造成射流集中、稳定，而且减小了熔体浇铸时的喷射阻力，提高了冷却速度。

4. 母合金熔化后，由于通过电磁阀给合金熔体瞬时施加一定压力的气体，造成石英喷嘴和真空体内的瞬时气压差，使石英喷嘴内的合金熔体高速喷射铸入铜模中，提高了冷却速度，从而提高了非晶形成能力。

5. 由于真空体采用玻璃制造，所以可以通过透明的真空体清楚地观测整个浇铸过程，便于控制浇铸过程，提高块体非晶态合金制备的成功率。

6. 整个制备方法成本低，工艺简单，便于操作。

总之，通过本发明所述方法可以有效地提高合金熔体的冷却速度，成功地制备出

块体非晶态合金。采用本发明制备出的不含 Be 的 Zr-Al-Ni-Cu 块体非晶态合金的部分力学性能已达到含 Be 的高尔夫球杆端头用 Zr-Ti-Cu-Ni-Be 块体非晶的力学性能。除上述实例以外，采用本发明还成功地制备出直径是 4mm 的 $Nd_{60}Al_{15}Fe_{10}Cu_{10}Co_5$、$Nd_{60}Al_{15}Fe_{10}Co_{10}Cu_5$ 和 $Nd_{60}Fe_{20}Cu_{10}Al_{10}$ 等块体非晶态合金。该方法成本低，工艺简单，便于控制和操作。下面通过实施例详述本发明。

附图 1 块体非晶态合金的制备原理示意图。

附图 2 $Zr_{55}Al_{10}Ni_5Cu_{30}$ 块体非晶态合金的 X 射线衍射谱。

附图 3 $Zr_{57}Ti_5Al_{10}Cu_{20}Ni_8$ 块体非晶态合金的 X 射线衍射谱。

实施例 1:

实验设备如图 1 所示，1 抽气管(接真空抽气系统和高纯氩气)，2 夹具 3 石英套筒，4 石英喷嘴，5 高频感应线圈(接高频感应加热装置)，6 石英导流管，7 铜模，8 可调底座，9 底板，10 玻璃真空体。

原材料为纯金属 Zr、Al、Ni、Cu，其纯度分别为：Zr99.9%；Al99.9%；Ni99.5%；Cu99.9%。将原材料按 $Zr_{55}Al_{10}Ni_5Cu_{30}$ 的原子百分比置于电弧炉中，抽真空后通入高纯氩气，采用电磁搅拌进行熔化，反复熔化 2~3 遍使合金均匀化，制成母合金。

将母合金通过本发明进行制备，模具采用 $\Phi4\times60$ 和 $4\times30\times55$ 的铜模。其中，浇铸温度为：830℃~，气体压力为：1.2kgf/cm²。

通过本发明可以成功地制备出尺寸为 $\Phi4\times60$ 和 $4\times30\times55$ 的 $Zr_{55}Al_{10}Ni_5Cu_{30}$ 块体非晶态合金。

X 射线衍射的实验结果如图 2 所示。

实施例 2:

所用的纯金属为 Zr、Ti、Al、Cu、Ni，其纯度分别为：Zr99.9%；Ti99.9%；Al99.9%；Cu99.9%；Ni99.5%。母合金的成分为 $Zr_{57}Ti_5Al_{10}Cu_{20}Ni_8$（原子百分比）。模具采用 $\Phi4\times60$ 和 $2\times30\times55$ 的铜模。其中，浇铸温度为：1110℃~，气体压力为：1.3kgf/cm²。其余同实施例 1。

通过本发明可以成功地制备出尺寸为 $\Phi4\times60$ 和 $2\times30\times55$ 的 $Zr_{57}Ti_5Al_{10}Cu_{20}Ni_8$ 块体非晶态合金。

X 射线衍射的实验结果如图 3 所示。

比较例：

Zr 基块体非晶态合金已进入应用化阶段。美国的 W. L. Johnson 应用 Zr-Ti-Cu-Ni-Be（Be 含量超过 20%）块体非晶来生产高尔夫球杆端头，带来了巨大商业利润。

由于 Be 是一种有毒金属，含 Be 合金的生产带来很大问题，所以我们采用本发明制备出不含 Be 的 $Zr_{55}Al_{10}Ni_5Cu_{30}$ 块体非晶态合金，用以代替美国的材料，并测定了其力学性能．通过本发明制备的 Zr-Al-Ni-Cu 块体非晶和美国的 Zr-Ti-Cu-Ni-Be 块体非晶部分力学性能的结果如表 1 所示．

通过对比可以看出，两者的力学性能是非常相似的．可见采用本发明制备的不含 Be 的 Zr-Al-Ni-Cu 块体非晶态合金的部分力学性能已达到含 Be 的 Zr-Ti-Cu-Ni-Be 块体非晶的力学性能。

表 1　块体非晶态合金力学性能测试结果

力学性能	Zr-Al-Ni-Cu	Zr-Ti-Cu-Ni-Be
密度（g/cm^3）	6.44	6.1
硬度（kg/mm^2）	509	570
抗压强度（GPa）	1.6	1.8
抗弯强度（GPa）	2.7	2.8

说 明 书 附 图

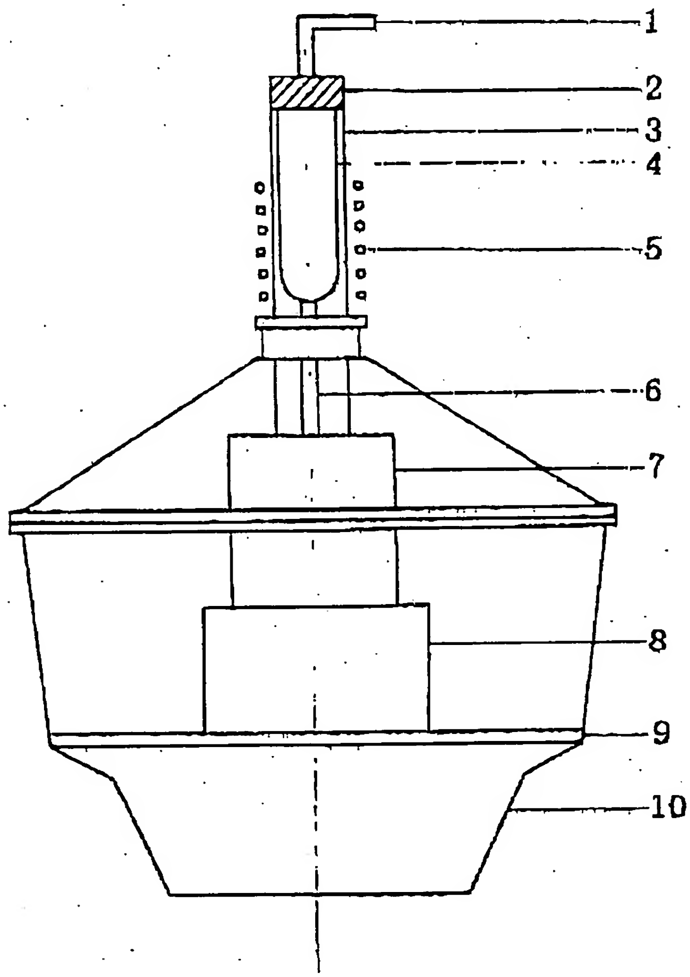

图 1

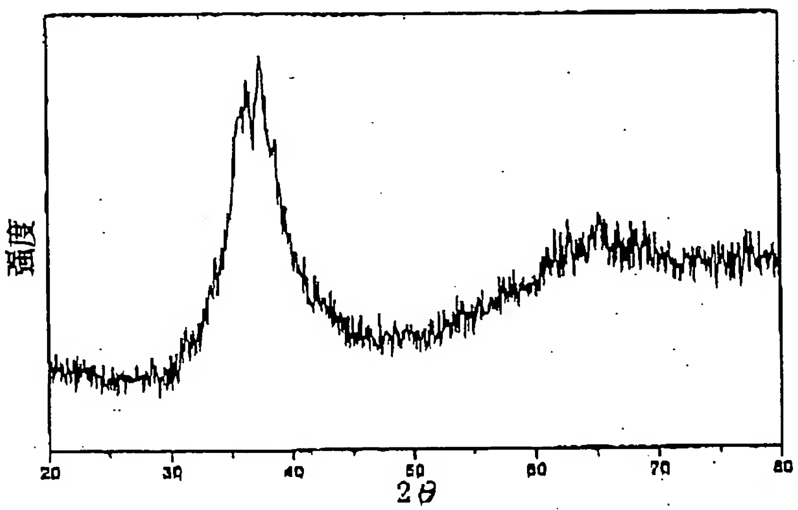

图 2

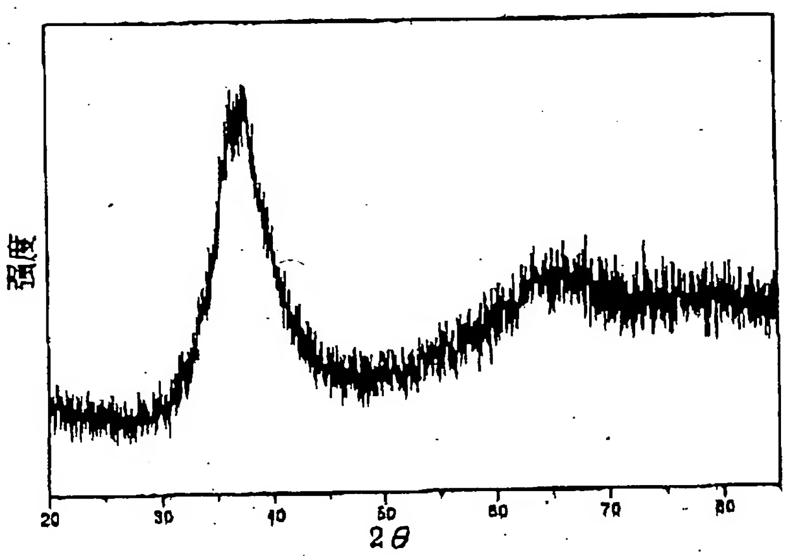

图 3